TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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THE CALCULATION OF WING FLOAT DISPLACEMENT IN SINGLE-FLOAT SEAPLANES.

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The lateral stability of all single-float seaplanes and flying boats except those of the Dornier type with lateral extensions on the hull itself must be assured by the use of auxiliary floats at the wing tips, these floats being mounted high enough so that they make contact with the water only when the seaplane is heeled over to one side or the other and so that only one of the wing floats can be in contact with the water at a given time.

In calculating the proper size for such wing floats, the stability of the main central float is often entirely neglected, the position of center of buoyancy being assumed independent of the angle of inclination. The weight carried by one of the auxiliary floats in still water and still air can then be calculated directly by taking moments around the center of buoyancy with the machine in the inclined position, and the total volume which the wing floats should have can be calculated if it is assumed that a fixed reserve of buoyancy is desirable there, just as it is for the main float. It is then necessary only to multiply the weight carried by the wing float under ideal conditions by a fixed constant to find the desirable total displacement. The application of this method has been explained in detail with calculations for a number of specific examples, in a recent publication (Reference 1).

The use of a fixed reserve of buoyancy has several possible disadvantages in certain special cases. In the first place, it is liable to lead to incorrect results for machines with a very low center of gravity, such as flying floats. The instability of the main float alone is small in such cases, and even a 100 percent reserve may represent a very small absolute addition to the size of the wing float. It will be observed that the reserve buoyancy of the wing floats is exceptionally large on most flying boats which have proven satisfactory in actual service. On the NC, for example, the reserve was 490 percent. A method which would give a constant independent of size and height of c.g. would obviously be desirable. Second, and by similar reasoning, the use of a constant reserve of buoyancy takes no account of the stability of the main float. It is conceivable that two different floats might be designed for a given machine, and that the negative lateral metacentric height with one of them would be 3 feet, while with the other it would be only 3 inches. Obviously, if the central float itself has a considerable measure of stability the size of the wing floats can be reduced. Third, the method involving a constant reserve of buoyancy cannot be applied at all in those cases where there is a small positive metacentric height. A hull of the Dornier type, for example, might be so designed as to locate the metacenter a few inches above the c.g. There would then be no weight carried on the wing float when the seaplane was at rest under ideal conditions, as the machine would float on an even keel, but, nevertheless, wing floats would actually be required under service conditions to provide a sufficiently large reserve of stability.

In seeking another method it seems logical to turn directly to the concept of metacentric height, always used in investigating the stability of a single floating object. When it is said that a twin float seaplane has a lateral metacentric height of 12 feet the implication is that the center of gravity could be raised 12 feet from its actual position before the machine would become laterally unstable in still water and would fail to return to its original position of equilibrium if slightly disturbed therefrom. A fictitious raising of the center of gravity may be used in an analogous manner in determining the size of the wing float. Instead of stating that such a float must have 100% reserve of buoyancy, it may be specified simply that the float must be large enough so that it would hold the wing out of water if the center of gravity were raised x feet from its present position, and that procedure overcomes all of the principal objections just stated against the other method.

Obviously, the height by which it should be possible to raise the center of gravity should bear some definite relation to the desirable metacentric height of a twin-float system. Diehl has shown (Reference 1) that present practice endorses the use of twin-floats so set that the transverse metacentric height is equal to 13 + .002 W, where W is the total weight of the airplane in pounds. Manifestly, however, it would be unnecessary to allow for raising the c.g. by that full amount when auxiliary floats are employed, as the auxiliary floats are normally out of the water and the inclining moments when running through waves are therefore much less than those arising when there are two main floats of equal size continually carrying the seaplane. Comparison of the characteristics for existing seaplanes, similar to the comparison made by Diehl in deriving his constants, suggests that on the average the center of gravity should be assumed raised by about one-half of the desirable metacentric height as given by Diehl's formula, but that the exact ratio should be a function of the angle of inclination to submerge the wing float completely and that it should vary lineally from a value of .8 at 3° inclination down to one of .2 at 12°, remaining constant for angles of inclination higher than that. Fig. 1 shows the nature of the variation.

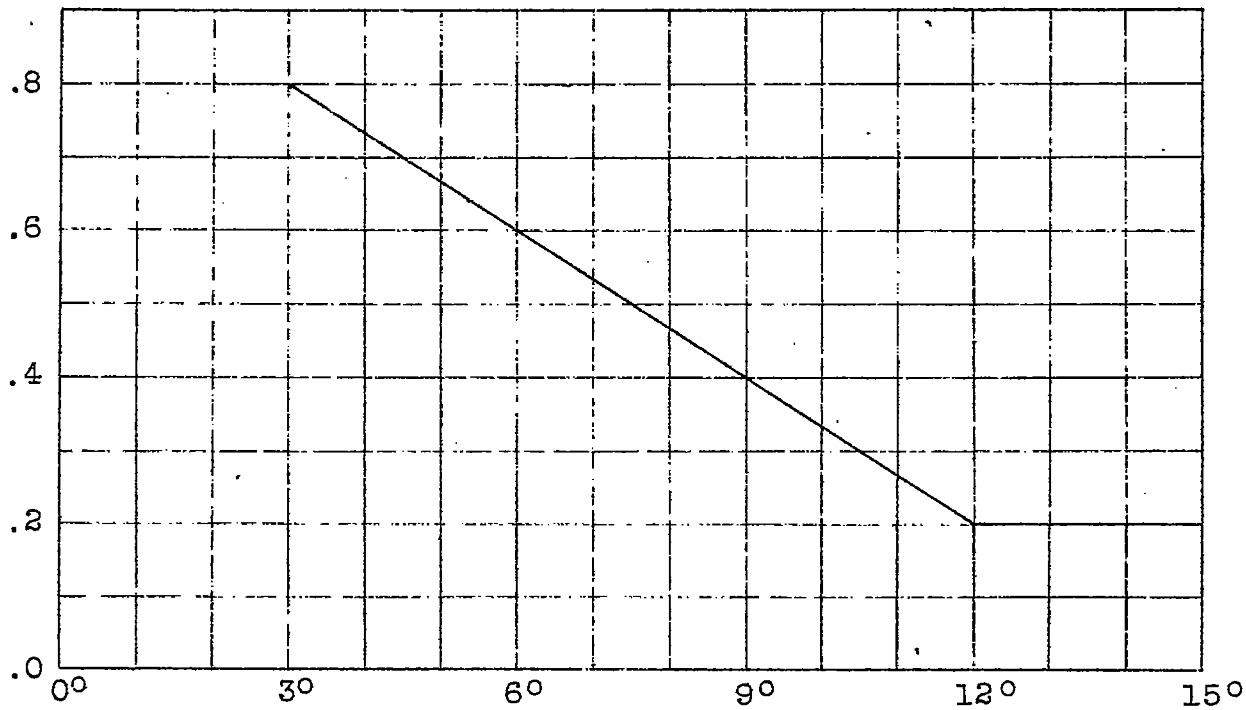

Fig. 1

The formula for the displacement of each wing float then becomes:

$$\Delta_W = \frac{W[GM + k\ (13 + .002\ W)]\tan\Phi}{s}$$

where Δ_W is the total buoyancy of a wing float, W the weight of the seaplane, GM its negative metacentric height, k the coefficient plotted in Fig. 1, Φ the angle of tilt to submerge a wing float, and s the distance from each wing float to the plane of symmetry of the seaplane.

Reference

1. W. S. Diehl: Static Stability of Seaplane Floats and Hulls. N.A.C.A. Technical Note No. 183. 1924.